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Orientation and Experience in the Perception of Form: A Study with the Arizona Whale–Kangaroo

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When subjects are presented with the Arizona whale–kangaroo, an ambiguous figure, perception of the whale is more common than perception of the kangaroo. However, this difference is smaller in Australian than American subjects. Perception of the kangaroo is more orientation dependent than perception of the whale, which is perceived at all orientations of the stimulus. Together with the difference between subject populations, this effect reveals an influence of past experience on the perception of this new ambiguous figure. Perception of the whale versus the kangaroo differs in both reconstrual of parts and realignment of the object-centered reference frame. Observers report reference frame reconstruals before reference frame reversals, shedding light on the organization of object memory.

KEYWORDS: perception, ambiguous figures, reversible figures, bistable figures, multistable figures, form perception, shape recognition, object recognition, orientation, past experience, category clustering, culture and perception

Ambiguous, reversible, or multistable figures, a class of visual phenomena of which the oldest and best known is Necker's cube (Necker, 1832; see also Hochberg & Peterson, 1987; Peterson & Hochberg, 1983), have long held an important place in the psychology of perception (e.g., Attneave, 1971; Fisher, 1968a; Palmer, 1999; Porter, 1938). Other familiar examples are the duck–rabbit, introduced by Jastrow (1899) and popularized by Wittgenstein (1953/1958) and Gombrich (1960); and the chef–dog, introduced

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by Rock (1956), based on the earlier clown–seal figure of Gibson and Robinson (1935). Large sets of ambiguous figures have been provided by Fisher (1967c, 1968a) and Lindauer and Baust (1974). Fisher (1967b) has also provided methodological notes on constructing and evaluating ambiguous figures (see also Porter, 1938; Price, 1969). For thorough reviews of reversible figures and their theoretical implications, see Long and Toppino (2004; see also Kornmaier & Bach, 2012; Leopold & Logothetis, 1999; Sterzer, Kleinschmidt, & Rees, 2009; Wimmer & Doherty, 2011).

Because the perceived image changes while the pattern of proximal stimulation remains unchanged, reversible figures are often taken as evidence for the contribution to perception of nonstimulus factors, including such central, top-down cognitive processes as expectation, intention, interpretation, memory for past experience, and perceptual problem solving (Gregory, 1970, 1974; Hochberg, 1968, 1978; Hochberg & Peterson, 1987; Peterson, 1993, 1994; Peterson & Gibson, 1994a, 1994b; Peterson & Hochberg, 1983; Rock, 1975, 1983, 1985). These factors operate in the context of other factors that contribute to reversal, such as neural fatigue (e.g., Kohler, 1940; Peterson & Hochberg, 1983) and the presentation of specific cues (Jensen & Mathewson, 2011).

When considering ambiguous or reversible figures, it is important to distinguish between two aspects of reversibility (Peterson, Kihlstrom, Rose, & Glisky, 1992). In reference frame realignments there is a change in object-centered directions, such as top versus bottom or front versus back. An example is the Necker cube, whose edges and corners remain edges and corners, no matter which way the cube is facing. In reconstruals, by contrast, a new interpretation is assigned to the components of the figure while the reference frame remains unchanged. Reversing the duck–rabbit stimulus in Figure 1 entails both a reference frame reversal (e.g., the front of the duck is the back of the rabbit) and a reconstrual of parts (e.g., the duck's bill becomes the rabbit's ears). Peterson et al. (1992) found that subjects typically report reconstruals of the duck–rabbit before they report reference frame reversals, especially when reporting reversals of a mental image of duck–rabbit.

The Arizona Whale–Kangaroo

In the course of previous research (Kihlstrom, Glisky, Peterson, & Harvey, 1991; Peterson et al., 1992), we began to look for ambiguous figures elsewhere (for a similar experience with the duck–rabbit, see Shepard, 1990). An interesting example appeared in a mobile of whales purchased at the Monterey Bay Aquarium (designed and manufactured by Jane Boyd Designs, P.O. Box 468, Point Reyes Station, CA 94956). One whale in particular, actually a humpback (*Megaptera novaeangliae*), swimming downward and to the right, when viewed in silhouette seemed to reverse into a kangaroo hopping to the left. We named this figure the Arizona whale–kangaroo (AWK). Figure 2 presents the final drawing of the figure, with smoothing

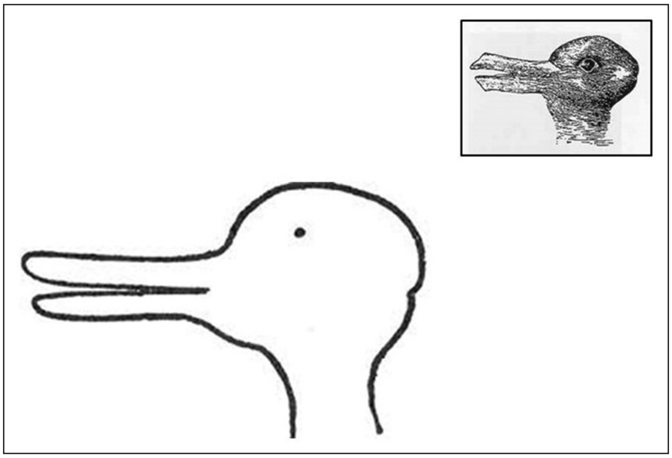

FIGURE 1. Schematic version of the duck–rabbit reversible figure popularized by Wittgenstein (1953/1958) and Gombrich (1960). Inset: The original figure published by Jastrow (1899)

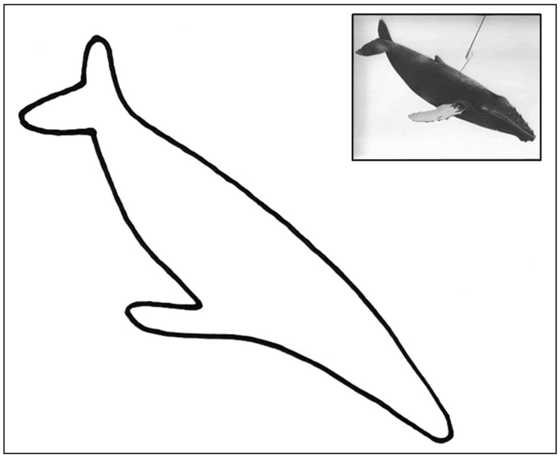

FIGURE 2. The Arizona whale–kangaroo (AWK), shown in 135° orientation. Inset: The original whale figure, from the mobile

of the original whale's hump and flipper and lengthening of its snout to better suggest a kangaroo's tail; the original mobile figure is in the inset. Reversing between whale and kangaroo entails both a reference frame reversal (e.g., the front of the whale is the back of the kangaroo) and a reconstrual of parts (e.g., the snout of the whale is the tail of the kangaroo).

PRELIMINARY STUDY: PERCEPTIONS OF THE WHALE–KANGAROO

Our first experiment was simply a pilot study intended to describe the AWK figure and document the various interpretations given for it.

METHOD

Subjects

After giving their consent, a total of 149 American college students participated in this experiment to partially fulfill the requirements for their introductory psychology class.

Stimulus Materials

The AWK stimulus figure was drawn in black ink on a white page oriented so that the whale's snout was pointed at 120° (or 4:00).

Procedure

Before the subjects were presented with the stimulus figure, they were read the following instructions:

> I'm going to show you a picture of an ambiguous figure. An ambiguous figure is a figure that can represent more than one thing. Please look at the picture and then list all the things it looks like to you.

The subjects were then shown the figure printed at the top of a sheet of paper and given 5 min to list their interpretations in the order that they came to mind.

RESULTS AND DISCUSSION

Four judges separately determined the top and bottom, and front and back, of each of the subjects' interpretations. Percepts specified by at least three judges to be in the same reference frames as the whale or the kangaroo were grouped into the same categories as these percepts (in most cases there was total agreement).

In scoring subjects' within-reference frame responses, we counted a number of alternative interpretations, such as *dolphin, shark, seal, fish, sea lion, sea otter, walrus,* and *manta ray* as equivalent to the "whale" percept and *fox, dog, rabbit, animal running, squirrel, cat, lion,* and *bear fetish* (this from one of our Native American subjects) as equivalent to the "kangaroo" percept. These alternatives were deemed equivalent to whales and kangaroos because they preserved the same object-centered reference frame (top/bottom, front/back), the same general semantic category (sea animals, four-footed animals), and the same component parts (fins, feet) as the targets. Although these interpretations may represent a reconstrual of parts without a reference frame realignment, we were unable to distinguish between a true perceptual reconstrual and a mere relabeling of a part (or the whole figure) in the absence of a genuine perceptual change. In the absence of evidence that whales, dolphins, and other sea animals were perceptually different, we counted these responses as equivalent percepts in this study (i.e., we did not consider them reconstruals). We mention these interpretations here so that the reader can understand that the AWK figure affords more than the two interpretations designated by its name.

Every subject saw the whale or an equivalent percept; by contrast, only 85 subjects (57%) saw the kangaroo or the equivalent. In addition to these target percepts, subjects often offered alternative percepts from the same category, such as *dolphin* or *dog*. Table 1 provides the details.

Occasionally, subjects offered other interpretations of the stimulus figure, such as *airplane, submarine,* and *surfboard* (for the whale) and *bird, bird on a branch, penguin, duck,* and *dinosaur* (for the kangaroo). These appeared to retain the same reference frame as the targets but were not counted as equivalent because they lay outside the target semantic category and also differed in terms of the identification of particular features. These nonequivalent interpretations were considered within-reference frame reconstruals.

A small number of other interpretations, such as *chair,* were not counted because they did not retain the reference frame of either the whale or the kangaroo. These alternative interpretations, which involve both realignment and reconstrual, lay outside

TABLE 1. Interpretations Given to the Arizona Whale–Kangaroo in Pilot Studies With American Subjects

Percept	% of Subjects
Whale reference frame	
Equivalent interpretations	
Whale	46.8
Dolphin	60.6
Shark	30.9
Seal	26.6
Fish	12.8
Sea lion	3.2
Sea otter	4.3
Walrus	1.1
Manta ray	1.1
Nonequivalent interpretations	
Airplane	30.9
Kangaroo reference frame	
Equivalent interpretations	
Kangaroo	54.3
Fox	3.2
Dog	3.2
Rabbit	2.1
Animal running	1.1
Squirrel	1.1
Cat	1.1
Lion	1.0
Nonequivalent interpretations	
Bird	4.3
Bird on a branch	3.2
Penguin	3.2
Duck	1.1
Other reference frame	
Chair	9.6
Miscellaneous: Amoeba, arrow, balloon, bone, bottle opener, cactus, cartoon character, cloud, coat hanger, cooking tool, corn, cornucopia, eel, fin of animal, fishing lure, ghost, golf bag, golf hole, Gumby, gun, hair clip, half-dog half-lizard, hand, head, island, kite, lake, map, mermaid, missile, mouth, piano, platypus, pond, porcupine, prongs, puddle, puzzle piece, Silly Putty, slug, smear of paint, torpedo, tree branch, vacuum cleaner, wrench	1.1–4.3 each

the target domains of *whale* and *kangaroo* and were also omitted from further consideration.

The results of the pilot experiment show that the AWK stimulus does support two primary interpretations—whale and kangaroo—as well as other interpretations within the reference frames of those two primary interpretations.

MAIN STUDY: EFFECTS OF ORIENTATION AND EXPERIENCE

In addition to introducing the whale–kangaroo figure, the primary purpose of this study was to investigate the effects of stimulus orientation and past experience on its perception. Orientation is important in the identification and recognition of unambiguous shapes that have a typical orientation (Gibson & Robinson, 1935; Jolicoeur, 1985, 1988; Tarr & Pinker, 1989). Performance is faster and more accurate when the stimuli are viewed in their typical upright orientation rather than disoriented from upright. The two objects resembled by the AWK are typically perceived under different conditions. The kangaroo is a land animal that is typically perceived with its head at the top. The whale is a sea creature that is perceived in many different orientations, swimming in the sea or leaping out of and diving into the sea. Thus, if orientation affects the perception of ambiguous stimuli, the AWK may be differentially ambiguous in different orientations. There is a general absence of orientation norms for ambiguous stimuli, even those whose reversal depends on a realignment of top/bottom specifications. For example, the chef–dog figure is typically presented at an orientation that affords some "chef" responses and some "dog" responses (Rock, 1956; Rock & Heimer, 1957); to our knowledge, perception of the chef–dog at other orientations has gone undocumented.

Orientation effects represent a form of past experience (cf. Peterson, 1994). Another form of past experience is the likelihood of having seen an object at all. In our preliminary study, it was obvious that not all American college students perceived the kangaroo or equivalent. It is possible that American students' experience with kangaroos is insufficient to affect the perception of this ambiguous stimulus for which there is another interpretation. Accordingly, in this experiment we tested both American and Australian subjects; the latter have more experience with kangaroos (and perhaps whales as well) than American subjects. If past experience affects the interpretation of ambiguous displays, Australian subjects should be more likely than American subjects to perceive the kangaroo or an equivalent interpretation.

METHOD

This study was originally planned as an experiment and exact replication, each involving samples of American and Australian college students drawn from different institutions. Because the results of the two experiments were so similar, with only minor differences in statistical outcomes, they have been combined in this report for ease of exposition.

Stimulus Materials

A total of 12 different versions of the AWK figure were prepared by rotation. For the first version, the figure was presented in an exactly vertical orientation (0°), with the snout of the whale at 12:00, its tail at 6:00, and its fin pointing to the right. Successive versions were prepared by rotating this figure every 30° clockwise. The version of the stimulus presented in Figure 1 is positioned at approximately 135°, with the whale's snout positioned between 4:00 and 5:00. Each subject saw only one version of the figure. Figure 3 shows AWK in the 0°, 90°, 180°, and 270° orientations.

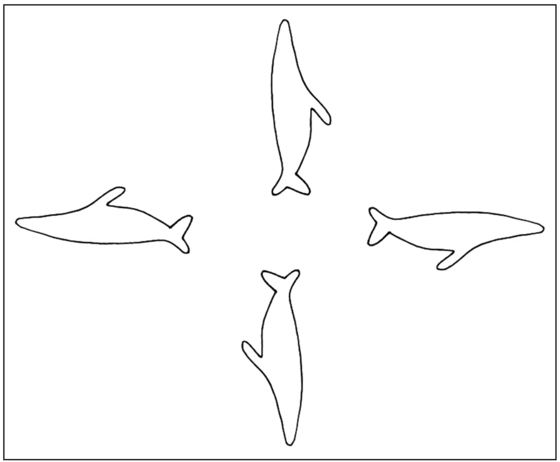

FIGURE 3. The AWK stimulus figure used in the main experiment, shown in four different orientations (clockwise from top: 0°, 90°, 180°, and 270°)

Subjects

The two American samples consisted of 450 undergraduates at the University of Arizona and another 494 undergraduates at the University of California, Berkeley (combined $N = 944$). The two Australian samples consisted of 491 undergraduates at Macquarie University and 608 undergraduates at the University of New South Wales (combined $N = 1{,}099$). At all four sites, the subjects participated in the study in return for credit toward the research participation requirement of their introductory psychology course. All subjects were run in small groups, each group randomly assigned to one of the 12 stimulus orientations. At least 61 American and 79 Australian subjects viewed each orientation.

Procedure

The procedure was the same as the preliminary experiment, except that in addition, the subjects were asked to rate the figure in terms of how convincing a rendition it was for each interpretation. Subjects used scale ranging from 1 (*Not very clear, vaguely resembles the object*) to 5 (*Very distinct, clearly resembles the object*).

RESULTS

With only four exceptions (all Australian), the whale, or some equivalent interpretation, was seen by every subject at every orientation (100% of the Americans, 99.6% of the Australians). By contrast, only 43.7% of the subjects saw a kangaroo or its equivalent. Two of the Australians who failed to see the whale nevertheless saw the kangaroo.

Perception of Whales and Kangaroos

Conceptually, this study was planned as a 2 × 12 × 2 mixed design with two between-group factors (population: American vs. Australian; orientation: 0° to 330°) and one within-subject factor (percept: whale or kangaroo). However, because almost every subject saw the whale at every orientation, the primary analysis was performed on the kangaroo percept only.

Not surprisingly, most subjects saw the whale first. Of the subjects who also saw the kangaroo, more Australians (12.0%) than Americans (5.1%) saw it before they saw the whale, $\chi^2(1) = 10.58, p < .001, r = .11$).

Figure 4 shows the proportion of subjects in each group, at each orientation, who saw the kangaroo or

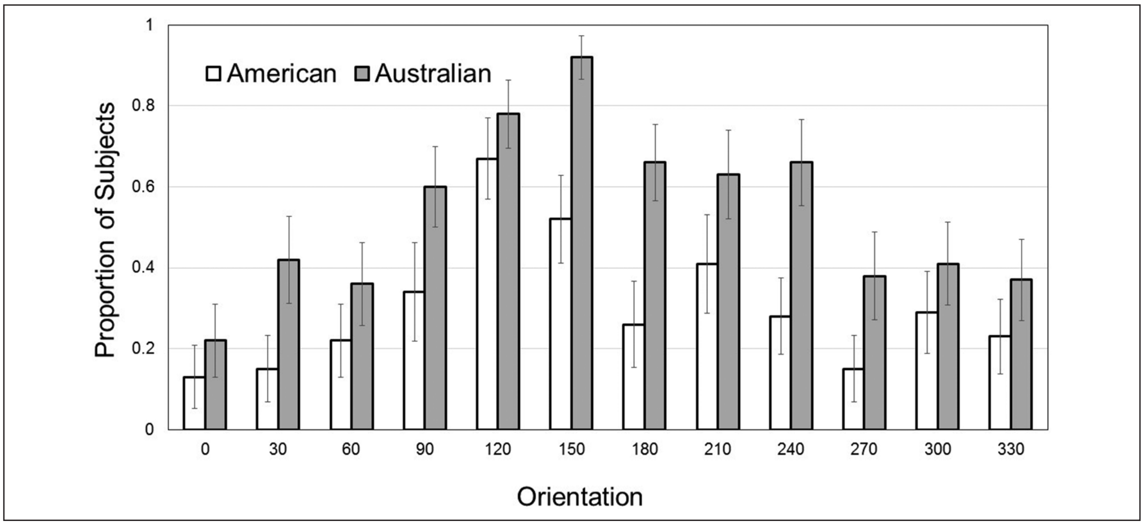

FIGURE 4. Proportion of subjects in each group perceiving the kangaroo (almost all subjects saw the whale). Error bars represent 95% confidence intervals

an equivalent percept (as defined in Table 1). There was a significant effect of orientation, $\chi^2(11) = 257.17$, $p < .001$, $r = .30$. Subjects were more likely to see the kangaroo at 120° and 150° (73% and 74%, respectively) than at the other orientations, $\chi^2(1) = 170.62$, $p < .001$, $r = .24$); arguably, these are the orientations that most closely match the typical person's mental image of a kangaroo, derived from pictures of kangaroos seen in books, or real kangaroos seen in zoos or in the wild. As expected, the Australian subjects were more likely than the Americans to see the kangaroo overall (54% and 31%, respectively), $\chi^2(1) = 113.88$, $p < .001$, $r = .29$. Individual χ^2 tests showed that the difference between Australian and American subjects was significant ($p < .05$) at every orientation except 0°, 120°, and 300° and was especially large at 30°, 150°, 180°, and 240° (all $p < .001$, all $r > .30$). The American subjects were most likely to see the kangaroo at the 120° orientation, $\chi^2(1) = 29.28$, $p < .001$, $r = .18$. By contrast, the Australians were most likely to see the kangaroo at the 150° orientation, $\chi^2(1) = 66.97$, $p < .001$, $r = .16$.

Resemblance Ratings

Figure 5 shows the mean resemblance ratings given to the whale and kangaroo percepts at each orientation. This analysis included only the 887 subjects (292 Americans and 595 Australians) who saw both the kangaroo and the whale. A 2 × 12 × 2 mixed-design analysis of variance was conducted with two between-group factors (population and orientation) and one within-subject factor (percept: whale or kangaroo). Overall, the figure was perceived as a more convincing rendition of a whale than of a kangaroo, $M = 3.95$ vs. 3.24, respectively, shown by a significant main effect of percept, $F(1, 863) = 276.90$, $MSE = 251.94$, $p < .001$, $\eta p^2 = .24$. This was to be expected, because the figure originated as an image representation of a whale. A significant population × percept interaction was observed, $F(1, 863) = 16.97$, $MSE = 15.44$, $p < .001$, $\eta p^2 = .02$. The difference between the resemblance ratings assigned to the whale and the kangaroo was larger for American students, $M = 4.36$ versus 3.27, respectively, $F(1, 291) = 228.23$, $MSE = 170.99$, $p < .001$, $\eta p^2 = .12$, than for the Australian subjects, $M = 3.74$ versus 3.22, respectively, $F(1, 594) = 77.36$, $MSE = 82.33$, $p < .001$, $\eta p^2 = .12$).

A significant percept × orientation interaction, $F(11, 863) = 4.18$, $MSE = 3.81$, $p < .001$, $\eta p^2 = .05$, was also obtained, The whale received fairly high resemblance ratings regardless of orientation, $F(11, 875) = 1.69$, *ns,* whereas the resemblance ratings for the kangaroo varied significantly with orientation, $F(11, 875) = 7.82$, $p < .001$. Bonferroni tests showed that the kangaroo received its highest resemblance ratings at 120°, 150°, and 180°. Main effects of orientation, $F(11, 863) = 5.56$, $MSE = 6.60$, $p < .001$, $\eta p^2 = .07$); and population, $F(1, 863) = 22.78$, $MSE = 26.88$,

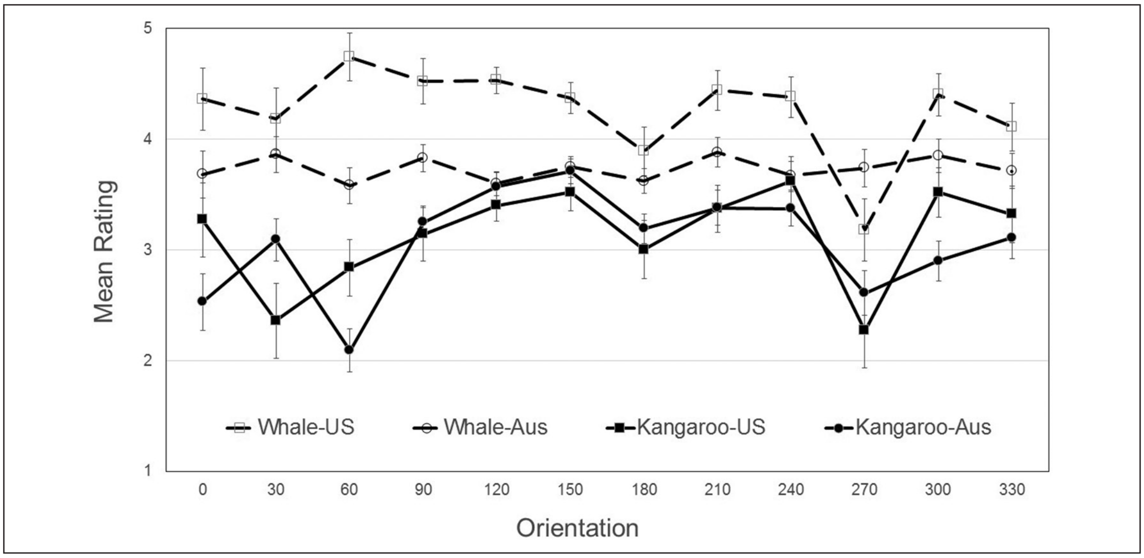

FIGURE 5. Mean resemblance ratings (on a 1–5 scale) of the whale and the kangaroo, at each of 12 orientations, based on the American and Australian subjects who perceived both objects. Error bars represent standard errors

$p < .001$, $\eta p^2 = .03$ were subsumed by the interaction effects. The three-way interaction, population × orientation × percept, did not approach statistical significance, $F(11, 863) = 1.34$, *ns.*

Organization of Perception

Next, we tested the hypothesis that subjects viewing ambiguous figures exhaust reconstruals within a particular reference frame before reversing the reference frame itself (Peterson, 1993; Peterson et al., 1992). For example, we predicted that in subjects' reports, whales, dolphins, and even airplanes would be clustered together, as would kangaroos, dogs, and birds.

This analysis followed procedures established for the study of clustering and other forms of organization in free recall (Murphy, 1979; Murphy & Puff, 1982; see also Wilson & Kihlstrom, 1986). A variety of measures have been devised for this purpose, and each has its advantages and limitations. Our chosen measure, the adjusted ratio of clustering (ARC), incorporates a correction for chance, but it cannot be calculated when subjects report items from only a single category, resulting in the loss of some subjects. For ARC, 0 reflects the amount of clustering expected by chance, and the index can take a value from below 0 (reflecting less than chance levels of clustering) to 1.0 (reflecting perfect clustering). The analysis used only the subjects run in the 120° and 150° orientations, which yielded the largest proportion of kangaroo percepts (105 of 106 Americans and 165 of 174 Australians, for whom ARC scores could be calculated).

The American subjects showed a fairly high level of clustering of percepts by reference frame ($M = 0.51$, $SEM = 0.08$). This value is significantly different from 0, $t(104) = 6.12$, $p < .001$, $d = 1.20$. Surprisingly, however, the Australian subjects showed lower levels of clustering ($M = 0.17$, $SEM = 0.08$). Although even this low level of clustering was significantly greater than chance, because of the large sample size, $t(164) = 2.05$, $p < .05$, the effect was much smaller, $d = 0.32$. The group difference in clustering was statistically significant, $t(268) = 2.82$, $p < .005$, $d = 0.36$.

DISCUSSION

There are essentially four classes of ambiguous figures. One involves only a reference frame reversal; the Necker cube and Schroeder staircase are classic examples. Another involves only a figure–ground reversal, as with Ruben's vase. Most ambiguous figures involve reconstrual of parts of the figure accompanied by either a figure–ground reversal (as in *Circumference IV* and other popular works of artist M. C. Escher) or a reference frame reversal (as in the duck–rabbit, wife and mother-in-law, and chef–dog).

AWK belongs in this last category. Upon first inspection, most subjects see a whale: when the reference frame reverses, the whale's snout becomes the kangaroo's tail, its tailfins become a snout and ear, and its flipper becomes a leg.

Not all subjects experience the reversal. Compared with the kangaroo, the whale was seen more frequently, was seen earlier, and received higher resemblance ratings. This asymmetry, in which the whale is more readily perceived than the kangaroo, does not impeach the status of the whale–kangaroo as an ambiguous figure. Other ambiguous figures are also asymmetric, although few of the classic ambiguous figures have been accompanied by the sort of normative data provided here. However, systematic comparisons of various versions of classic ambiguous figures make clear that many of them are not "equi-ambiguous" (Fisher, 1967a, 1967b, 1967c, 1968a; see also Girgus, Rock, & Egatz, 1977; Mitroff, Sobel, & Gopnik, 2006; Peterson, 1993; Peterson et al., 1992; Rock & Mitchener, 1992). Adult subjects find it easier to see a duck or other bird in most versions of the duck–rabbit figure, including Jastrow's original (Brugger, 1999)—except on Easter Sunday, when the rabbit strongly prevails (Brugger & Brugger, 1993). Introducing a three-aspect version of the "wife and mother-in-law" figure, Fisher (1968b) reported that 41% of the subjects tested failed to see the "daughter" as well as the "mother" and "father."

Although the whale was seen, and seen with approximately equal conviction, at all orientations, the subjects were most likely to identify the shape as a kangaroo when it was at the 120° or 150° orientations. These orientations also yielded the highest resemblance ratings. Of course, there is a large literature on the effects of orientation on the perception of form (e.g., Gibson & Peterson, 1994; Jolicoeur, 1985; Maki, 1986; Rock, 1974; Tarr & Pinker, 1989; for a review, see Peterson & Kimchi, 2013). Observers are typically highly accurate in recognizing disoriented versions of unambiguous shapes, although recognition is slower than when shapes are viewed in their typical upright. Apparently, a process of normalization compensates for stimulus disorientation before recognition.

Why, then, do more subjects not recognize the kangaroo regardless of the orientation of the stimulus? Perhaps the likelihood of matching a given representation (in this case, the kangaroo) during the normalization process depends on other factors in addition to the goodness of the depiction. Among these relevant factors are the degree to which the stimulus matches other representations (in this case, the whale), and the likelihood of seeing the depicted object in a particular orientation relative to the retinal or environmental frame (i.e., people see whales in all orientations in their ocean environment but kangaroos in their more restrictive terrestrial environment). This suggests that in perception, as well as in mental imagery, the availability of an interpretation within a given reference frame may interfere with perception of a construal in another reference frame. Our results indicate that the availability of an interpretation within a given reference frame depends on culture or experience.

This study is the first to identify cultural differences in the perception of ambiguous figures. Compared with American subjects, Australian subjects were more likely to see the kangaroo than were Americans, and their perceptions were less dependent on the orientation of the figure. They were also more likely to see the kangaroo before they saw the whale. In addition to shedding light on the importance of orientation in form perception, then, this research underscores the role played in perception by sociocultural factors relating to the experiences of the subjects and their familiarity with the objects of regard.

It seems unlikely that Australians are more prone than Americans to neural fatigue, sensory satiation and adaptation, and other peripheral or sensory factors often assumed to underlie perceptual reversibility. In contrast, they are certainly more familiar with kangaroos (real, depicted, and imagined) than Americans are. Other investigators have documented the effects of experience on perception, but these studies have been largely confined to exposures in the laboratory (Bugelski & Alampay, 1961; Goolkasian, 1987; Leeper, 1935; for an exception, see Peterson & Gibson, 1994a, 1994b). This cultural difference we report here adds to the growing body of evidence that "central," "cognitive," and "top-down" processes are involved in the resolution of perceptual ambiguity. That is, the frequency with which the Australian subjects recognize the kangaroo might reflect the relative richness of their memory representations of that animal. Ambiguity, then, is not just a property of the stimulus figure; it also resides in the eye (or the mind) of the beholder, as argued by Jastrow (1899) and, more recently, theorists such as Gregory (1970). The likelihood of seeing the kangaroo depends on structural knowledge embodied in the subject's mental representation of the shape of a kangaroo, as well as other factors, both peripheral and central, sensory and cognitive. This knowledge, in turn, is a product of learning situated in a particular cultural context.

In addition to being an interesting (and often amusing) class of perceptual stimuli, ambiguous figures are of interest for what they can tell us about perceptual processes more generally. It is central to the Helmholtzian constructivist view that stimuli are typically ambiguous, in that they can support a number of different interpretations. Perception then becomes a constructive process of problem solving, the problem being to find the best match between the features of the stimulus and the features of object representations stored in memory.

The clustering of alternative percepts according to reference frame, shown here for the first time via cluster analysis, may shed new light on this problem of perceptual problem solving (cf., Peterson, 1993; Peterson et al., 1992). Clustering may reflect the process of matching the stimulus features with the best representation stored in memory. Presented with AWK, for example, a subject might first perceive the figure as a whale, then as a porpoise, and even as an airplane (these are all within-reference frame reconstruals), before reversing the percept into a kangaroo, then a dog, and even as a bird perched on a branch (interpretations within a different reference frame). Both groups showed this tendency, although the Australians did so less strongly, perhaps because their experience with kangaroos led them to reverse more readily between the whale and kangaroo reference frames at the outset. Even if two subjects report the same percepts, one who immediately reverses between the whale and kangaroo reference frames and back again will necessarily receive a lower clustering score than one who reports several within–reference frame percepts before shifting to the other reference frame. When viewing ambiguous figures of this sort, it seems that perceivers search through candidates within a reference frame before reversing the reference frame and recommencing the search through shape memory (cf. Peterson, 1993; Peterson et al., 1992). Sociocultural differences may well play a role in the perception of other ambiguous (and unambiguous) figures where there are clear group differences in exposure and experience. But the process of organized search through shape memory may well be universal.

NOTES

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